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# Evocation Processes by Novice and Expert Designers: Towards Stimulating Analogical Thinking

Nathalie Bonnardel and Evelyne Marmèche

**Design activity occurs in many professions, ranging from technical to more artistic domains. Whatever the domain, it is a constant challenge for designers to introduce creativity in each design project they work on and minimize the tendency to repeat familiar design features. The goal of this paper is to present a cognitive approach to design problem solving as well as an experimental study. This study aims at determining whether creative ideas can be enhanced by the presentation of external sources of inspiration. In particular, we analyse the effect of the presentation of different kinds of sources (intra-** ***versus*** **interdomain sources, which are presented as graphical representations or as verbal labels) according to the designers' level of expertise (lay-designers** ***versus*** **professionals). Results show that it is possible to enhance evocation processes in design, but that it is dependent on both the nature of sources of inspiration and the designers' level of expertise. Based on these results, we suggest ways for enhancing creative ideas in design tasks.**

## Introduction

Design activities are performed in a very large range of professional areas, such as the design of everyday life products (e.g. Norman, 1993), website design (e.g. Bonnardel, Lanzone & Sumner, 2003), software design (Détienne, 2001) or even the design of aerospace products (Bonnardel, 1999). Whatever the design area, the final products have both to be useful, usable and attractive for customers or users. The usefulness depends on the functionality planned for the products at hand, which should be in accordance with users' needs. In order to create usable (or easy to use) products, designers can refer to guidelines and ergonomic principles or criteria (see, for instance, Norman, 1993; Nielsen, 1993, 2000; Scapin & Bastien, 1997). Though applying guidelines or ergonomic criteria appears not to be easy (Bonnardel & Chevalier, 2001; Chevalier & Ivory, 2003), designers can attend human-computer classes and training in order to reach more usable products. Developing attractive products is also a major challenge, since the decision of purchase frequently depends on the users' first feelings about the considered product.

So the first main question is: how to stimulate the design of such useful, usable and attractive products? Our objective in this paper is to better understand how creative ideas occur in design activities, and whether it is possible to enhance the emergence of such ideas by stimulating analogical thinking.

The role of analogy-making in creativity has been stressed by several authors; for instance, Koestler (1975), Kolodner (1993) and Boden (1990). Analogical thinking is also considered as having a positive role in creative design activities or in 'cognitive generative tasks' (see Bonnardel, 2000; Ward, Smith & Vaid, 1997). Koestler (1975, p. 121) explained creativity as 'the sudden interlocking of two previously unrelated skills, or matrices of thought'. According to Ward, Smith and Vaid (1997), people engaged in generative cognitive activities have to extend the boundaries of a conceptual domain by mentally crafting novel instances of the concept.

This paper first presents a cognitive approach that characterizes design problem-solving and describes cognitive mechanisms involved in creative design activities. Next, an experimental study is described. It aims both at determining whether it is possible to define

experimental conditions that enhance evocation processes in design and whether such conditions are dependent on the designers' level of expertise. Lastly, based on the obtained results, we suggest ways for enhancing evocation processes in designers' thinking.

## Creativity in design: A cognitive psychology view

### *Design problem solving*

In cognitive psychology, design activities are described as *problem-solving* situations: designers have to produce an artefact, which should fit a specific function and satisfy different requirements (Malhotra et al., 1980).

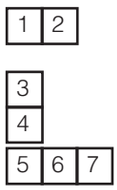
These requirements define to some extent the goal to reach, but designers have to complement their mental representation of the design problem, since these problems are *ill-structured* or *ill-defined* (Eastman, 1969; Reitman, 1964; Simon, 1973). Indeed, at the beginning of the problem, the designers have only an incomplete and imprecise mental representation of the design goal. It is only through the problem-solving process itself that designers can complete their mental representations by choosing design options (see Falzon et al. 1990). Thus, the design problem solving results from a *co-evolution of problem and solution spaces* (Cross & Dorst, 1999; Dorst & Cross, 2001). This specificity of design problems has also been described as based on an iterative dialectic between *problem framing and problem solving* (Rittel & Webber, 1984; Simon, 1995). During problem framing, designers refine design goals and specifications and, thus, refine their mental representation of the problem. During problem solving, designers elaborate solutions and evaluate these solutions with respect to various criteria and constraints, which guide the designers in performing subsequent stages of design problem solving (see, for instance, Bonnardel, 1993, 1999). Continuous interactions between the problem space and the solution space allows a *reflective conversation* between the designer and his/her external representation of the artefact (see Schön, 1983).

Each designer constructs his or her own mental representation of the design problem and deals in fact with a problem which has become specific to him or her. Different designers dealing with a same problem, develop different ideas and reach different solutions, materialized, for instance, by drawings or plans (Bisseret, Figeac-Létang & Falzon, 1988).

Design problems are also considered to be *open-ended* since there is usually no single correct solution for a given problem, but instead a variety of potential solutions (Fustier, 1989), which satisfy different criteria or constraints to varying degrees.

## Opportunistic process

The dialectic process between problem framing and problem solving contributes to another characteristic of design problem solving: it is viewed as an *opportunistic process*. Several years ago, much debate centred on whether design activities were hierarchically organized (see, for instance, Adelson & Soloway, 1985; Jeffries et al., 1981) or opportunistically organized (for a review, see Visser, 1994). The seminal study of Hayes-Roth and Hayes-Roth (1979) and later research (see, for instance, Bisseret, Figeac-Létang & Falzon, 1988; Guindon, 1990; Visser, 1990) provided arguments on behalf of an opportunistic organization of design activities, though they possibly include hierarchical episodes. The design process was thus described as multidirectional: decisions included both top-down and bottom-up instances and they could be made at different levels of abstraction etc. Such an activity was characterized by the authors as opportunistic because 'each decision [was] motivated by one or two immediately preceding decisions, rather than by some high-level executive program' (Hayes-Roth & Hayes-Roth, 1979, p. 381). Such decisions could lead to reconsidering previous decisions or postponing certain decisions (Bonnardel, Lanzone & Sumner, 2003; Hayes-Roth & Hayes-Roth, 1979; Visser, 1990).




## Emergence of new ideas

Understanding how designers opportunistically develop new ideas and reach innovative products remains a major issue. Models of creativity have been proposed in order to highlight the sociocultural context in which individual creativity occurs (see Boden, 1990; Csikszentmihalyi, 1996; Fischer, 2000; Liu, 2000). Other approaches describe characteristics of creative individuals (e.g. motivation, attitude, knowledge, skills) in relationship with positive or negative effects of the environment (Amabile, 1996). In particular, the 'investment approach' (Sternberg & Lubart, 1991, 1995) points out necessary resources for creative persons (e.g. intelligence, knowledge, motivation and so on) as well as the necessity

of presenting the new production at the right moment for the production to be appreciated.

Since our objective is to understand more precisely how the designers' mental representations evolve in order to reach an innovative production, we are going to focus on cognitive processes developed by designers, in line with cognitive-components approaches of creativity (see Finke, Ward, & Smith, 1992; Mumford et al., 1991; Runco & Chand, 1995).

Based both on observations in professional design situations (Bonnardel, 1992; Dorst, 1997; Valkenburg & Dorst, 1998) and previous experiments involving real design problem-solving activities (Bonnardel, 2000), we argue that evocation process in design is based on two main cognitive mechanisms which continuously interact:

- The construction of a *'constrained cognitive environment'*, which delimits the space of research, on the basis of different kinds of constraints, in order quickly to reach in-depth levels of understanding. These constraints can consist of prescribed constraints derived from a schedule of conditions, 'constructed' constraints which depend on the designers' expertise, or 'deduced' constraints, which depend on the current state of problem solving as well as on previously defined constraints (see Bonnardel, 1993). Constraints are propagated during design problem solving (Darses, 1994) and they dynamically orient the designer's reasoning towards the most appropriate decision-making and choices of design options (Bonnardel, 1999).
- *Analogy-making*, which can open up or restrict the 'space of research' of new ideas, depending on the nature of the sources that are evoked for solving the problem at hand. Design activities would be more or less creative according to the conceptual domains evoked sources belong to, and to the features of sources taken into account, such as functional, aesthetic or structural features (see Bonnardel & Marmèche, 2003).

## Analogy making and expertise

A lot of results showed that the cognitive treatment of data is performed differently depending on the participants' level of expertise (see, for instance, Bonnardel & Marmèche, 2003; Chi, Feltovitch & Glaser, 1981; Besnard & Bastien-Toniazzo, 1999; Didierjean & Marmèche, 2003;). Case-based reasoning is a usual cognitive process for experts, since they have a large library of cases at their disposal. Experts can refer to such cases in order to engage in analogy-making for solving design problems. Analogy-making is, however, double-edged:

- on one hand, it allows experts to consider promising ways for designing a new object;
- on another hand, it can restrict the boundaries of the space of research, the extent of design ideas, the range of procedures to be used and thus, reduce creativity.

In contrast, novice designers have only a few reference cases to deal with new design problems, which may restrict their space of research of innovative ideas.

Analogy-making is usually described as allowing two kinds of analogies:

- intradomain analogies, when the target (e.g. the situation or problem at hand) and the source (a previous similar situation) belong to the same conceptual domain;
- interdomain analogies, when the target and the source belong to different conceptual domains.

In addition, relationships are established between the target and the source. Intradomain analogies would be based on both surface similarities and structural similarities between the target and the cible, whereas interdomain analogies would be based only on structural similarities (or underlying principles) between the target and the sources.

A way to influence people in developing ideas is to provide them with suggestions or examples. Thus, several experiments were conducted, in the case of 'cognitive generative tasks', in order to determine the impact of the presentation of examples on participants' productions. Experimental tasks were defined in various areas: to design technical artefacts, such as spill-proof mugs or bicycle racks (Jansson & Smith, 1989, 1991; Purcell & Gero, 1992), to design novel space creatures to inhabit a distant planet, to provide novel ideas for reducing traffic accidents (Marsh, Landau & Hicks, 1996; Smith, Ward, & Schumacher, 1993; Ward, 1994; Ward & Sifonis, 1997). Whatever the final objective, mainly similar results were observed: when they are provided with examples, participants' productions *conform to experimenter-provided examples*. Such an effect has been called 'design fixation effect' in the case of design activities (Jansson & Smith, 1989, 1991). This type of effect appears, to a certain extent, similar to phenomena described for years, in psychology, under the terms of 'functional fixedness' and 'mechanisation of thought' (see Duncker, 1945; Luchins, 1942; Maier, 1931, Weisberg, 1988).

In contrast to these results, we argue that it is possible to enhance the evocation of new ideas and, especially, to lead designers to

extend their space of research, by providing them with different kinds of sources of inspiration. The objectives of our study are to determine:

- What is the nature of the sources of inspiration spontaneously evoked by lay designers and professionals.
- Whether it is possible to support designers in extending the boundaries of the conceptual domain related to the object to be designed, by providing them with different kinds of sources.
- Whether designers' evocation processes are different according to their level of expertise.

## Experimental study

*Hypotheses*

- Throughout the design activity, professional designers should globally evoke more intra- and interdomain sources than lay designers, since they are used to make analogies in their professional activities.
- In line with previous research about the design fixation effect, we expected that designers, whatever their level of expertise, would evoke mainly intra-domain sources directly related to the object to be designed.
- However, we hypothesized that professional designers may extend their space of research of ideas, when they are provided with interdomain sources. The suggestion of interdomain sources could lead professionals to develop a reflection based on principles underlying these interdomain sources, and to adopt various points of view, which lead them to evoke new creative ideas. In contrast, we hypothesized that lay designers will be more focused on surface features of the object to be designed. Therefore, they would not realize the potential interest of interdomain sources, which are apparently far from the object to be designed.

In addition, we compared two formats of presentation of the suggested sources: graphical representations versus verbal labels. In previous research, examples were always presented as graphical representations, which could limit the space of research more than verbal labels.

*Participants*

75 designers participated in this study:

- 25 professionals, who have been working in design offices for at least three years. They were between 26 and 66 years old and they had superior degrees in industrial design, graphical or applied arts, architecture. With regard to these characteristics, participants were assigned to each of the five experimental groups, in order to have matched groups.
- 50 'lay designers', who were students in their first or second year of Psychology, and who had no experience at all in industrial design.

## Experimental task

All the participants had to perform the same task: to design a new seat (see Figure 1). This task was defined in collaboration with a professor of industrial design and presented to participants as a scenario describing the object to design and its use, as well as the main requirements to satisfy. The object they had to design belongs to a category of objects well-known by everyone, novice or expert, since it is a specific seat. Participants had to express ideas and evoke sources, and though they realized drawings, our analysis is not focused on the quality of the drawings (which would require more technical skills), nor on their role

The object to be designed was intended to be used in a Parisian 'cyber-café'. It should be a particular seat with a contemporary design in order to be attractive for young customers. Such seats should allow the user to have a good sitting position, holding the back upright. Towards this end, the users should put their knees on a support intended to this function. In addition, these seats should allow the users the opportunity to relax, by offering them the possibility of rocking.

*Figure 1. Brief Description of the Object to Design.*

in the design task. Data analyses are only focused on the evoked sources, either without any suggested source of inspiration, or after the presentation of some sources, intra- or interdomain.

### *Experimental conditions and procedure*

The participants had to solve the design problem in their own office. They were assigned to groups corresponding to the following experimental conditions:

- a 'free' condition, in which the participants were only provided with the description of the design problem.
- Four 'guided' conditions in which the participants were first provided with the description of the design problem and, immediately after, with two potential sources of inspiration. These sources were either *intra*-domain or *inter*domain sources, and presented in a *verbal* or in a *graphical* format (see Figure 2).

The suggested *intra-domain* sources pertain to the 'seat' category, which is the category the object to be designed belongs to. They consist of a rocking chair and an office chair. The suggested *interdomain* sources do not belong to the category of the object to be designed. They consist of a climbing position and a logo.

Each participant had about 50 minutes to begin to solve the design problem at hand. The designers' drawings were video-recorded in order to allow us to analyse their evolution. In addition, in order to allow us to identify the sources of inspiration they referred to, the participants were invited to think aloud (see Dorst & Cross, 2001; Ericsson & Simon, 1993; Gero & Mc Neil, 1998; Piolat & Pélissier, 1998). The designers' verbalizations were transcribed in order to perform an analysis of new evoked sources.

### *Data analysis*

Since we focused on the designers' evocation processes, two indicators related to these processes were taken into account:

- the number of new sources evoked by the designers all along the design activity;
- the nature of new evoked sources, by distinguishing intra-domain sources and interdomain sources.

By 'new' sources of inspiration, we mean that, for the four guided conditions, the account was performed on sources of inspiration that were not the suggested ones, but really newly evoked sources (for instance, a camping seat, a sledge, a wave or a nest).

Three judges independently categorized these sources as being intra- or interdomain sources. A high degree of agreement was obtained (0.95). In case of hesitation, a short discussion allowed us to reach a complete agreement.

### *Results*

#### *Number and nature of sources evoked by laydesigners and professionals in the free and guided conditions*

A first ANOVA was conducted on the number of evoked sources, with the 'expertise level' (lay designers versus professionals) and the 'kind of condition' (free condition versus guided conditions) as between-subject factors. The results yielded a significant effect of the expertise level $F(1,71) = 10,33$; $MSe = 14,32$; $p < 0.01$. The effect of the conditions was non-significant. The results indicated no significant interaction between expertise level and kind of conditions.

A second ANOVA was conducted on the 'nature of the evoked sources' (intra- versus interdomain sources), with the 'expertise level' (lay designers versus professionals) and the 'kind of condition' (free condition versus guided conditions) as between-subject factors. The results indicated three significant interactions: the interaction between expertise level and the nature of the evoked sources, $F(1,71) = 5,96$; $MSe = 5,71$; $p < 0.05$, the interaction between the kind of conditions and the nature of the evoked sources, $F(1,71) = 4,22$; $MSe = 5,71$; $p < 0.05$, and the triple interaction between expertise level, kind of conditions and nature of the evoked sources, $F(1,71) = 4,63$; $MSe = 5,71$; $p < 0.05$.

In accordance with our first hypothesis, lay designers evoked less sources than professionals: in mean, respectively, 2.9 versus 6.4 (see Table 1). Thus, with the acquisition of expertise, the space of research is extended.

In line with our second hypothesis, whatever their level of expertise, designers spontaneously evoked (i.e. in the free condition) more intra-domain sources than interdomain sources (see Table 1).

The effect of the 'condition' factor (i.e. free versus guided conditions) is not globally significant: there is no significant difference in the number of sources evoked in the 'free' condition versus in the different 'guided' conditions taken together. However, planned comparisons show that though there is no significant effect for lay designers, for professionals, a significant interaction between conditions and the number of evoked sources does exist (intra- and interdomain sources). In the free

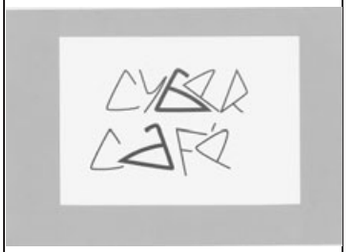
| Nature of sources<br><br>Format of presentation | Intradomain | Interdomain |
|---|---|---|
| Graphical representations |  <br>  |  <br>  |
| Verbal labels | OFFICE CHAIR<br><br>ROCKING-CHAIR | CLIMBING POSITION<br><br>LOGO |

*Figure 2. Suggested Sources of Inspiration*

*Table 1. Number and Nature of Sources Evoked by Lay Designers and Professionals in the Free and Guided Conditions*

| **Experimental conditions** | | **Free condition** | **Guided conditions** |
|---|---|---|---|
| **Level of expertise** | | | |
| Lay designers | Intra | 1.8 | 2.0 |
| | Inter | 1.1 | 1.2 |
| | Total | 2.9 | 3.2 |
| Professionals | Intra | 3.4 | 1.6 |
| | Inter | 3.0 | 5.6 |
| | Total | 6.4 | 7.2 |

condition, professionals mainly evoked intra-domain sources, whereas it is the reverse in the guided conditions, in which interdomain sources are predominant.

*Number and nature of sources evoked by lay designers and professionals according to the kinds of suggested sources and their format of presentation*

A first ANOVA was conducted on the number of evoked sources, with the 'expertise level' (lay designers versus professionals), the kind of 'suggested sources' (intra- versus interdomain sources) and the 'presentation format' (graphical representations versus labels) as between-subject factors. The results yielded a significant effect of the expertise level, $F(1,52) = 15,52$; $MSe = 13,40$; $p < 0.001$, a significant effect of the factor 'suggested sources' $F(1,52) = 9,56$; $MSe = 13,40$; $p < 0.01$ and a significant interaction between the factors 'expertise level' and 'suggested sources' $F(1,52) = 12,89$; $MSe = 13,40$; $p < 0.001$. The effect of the presentation format was non-significant, nor any interaction involving this factor.

A second ANOVA was conducted on the nature of the evoked sources (intra versus inter), with the 'expertise level' (lay designers versus professionals) and the kind of 'suggested sources' (intra- versus interdomain sources) as between-subject factors. The results indicated a significant effect of the expertise level, $F(1,56) = 16,05$; $MSe = 6,48$; $p < 0.001$, of the suggested sources, $F(1,56) = 9,88$; $MSe = 6,48$; $p < 0.01$] and of the number of intra versus interdomain sources that are evoked, $F(1,56) = 11,75$; $MSe = 5,63$; $p < 0.01$]. The interaction between expertise level and the kind of the suggested sources is significant, $F(1,56) = 13,33$; $MSe = 6,48$; $p < 0.001$. The interaction between expertise level and the nature of the evoked sources is significant, $F(1,56) = 26,71$; $MSe = 5,63$; $p < 0.001$. The interaction between the suggested sources and the evoked sources is also significant, $F(1,56) = 12,12$; $MSe = 5,63$; $p < 0.001$. The triple interaction between expertise level, suggested sources and nature of the evoked sources is not significant.

To summarize, for lay designers, the suggestion of sources, whatever they are intra- or interdomain, did not appear to enhance the production of new creative ideas.

In contrast, for professionals, the interdomain condition significantly facilitated the evocation of sources (in mean, 10.5 evoked sources), whereas the intra-domain condition appeared to limit the evocation of sources (in mean, 3.8 evoked sources) with regard to the result obtained in the free condition (6.4 evoked sources). In the guided conditions, whatever the nature of suggested sources, professionals evoked more interdomain sources than intra-domain ones (see Table 2). However, the space of research of interdomain sources appears to be even larger for professionals when they are provided with interdomain sources (in mean, 8.3) than with intra-domain sources (in mean, 2.8).

Thus, expertise seems to be related to the possibility of accessing interdomain sources, *a priori* far from the object to design.

No significant difference due to the format of presentation (graphical representations or verbal labels) of the initially suggested sources was observed, whatever the designers' level of expertise.

## Discussion

This study highlights interesting findings:

- The evocation of creative sources of inspiration mainly results from analogy-making with interdomain sources.

*Table 2. Number and nature of sources evoked by lay-designers and professionals in the guided conditions, according to the nature and format of presentation of suggested sources*

| **Suggested sources** | | **Intra-domain sources** | | **Interdomain sources** | |
|---|---|---|---|---|---|
| **Level of expertise** | | **Graphical** | **Verbal** | **Graphical** | **Verbal** |
| Lay-designers | Intra | 3.3 | 2.0 | 1.3 | 1.4 |
| | Inter | 0.2 | 1.4 | 1.4 | 1.8 |
| | Total | 3.5 | 3.4 | 2.7 | 3.2 |
| Professionals | Intra | 0.8 | 1.2 | 2.2 | 2.2 |
| | Inter | 1.6 | 4.0 | 9.2 | 7.4 |
| | Total | 2.4 | 5.2 | 11.4 | 9.6 |

- It is possible to exert an influence on the designers' evocation processes, but this influence depends on the designers' level of expertise.

Our results appear very different from previous findings (such as the ones of Jansson & Smith, 1989, 1991):

- For lay-designers, the presentation of sources of inspiration – playing the role of examples – did not limit the number of new evoked sources, though it did not expand it.
- In contrast, for professionals, we observed a limitation of the evocation of sources when they were provided with intra-domain sources. This result is in line with the one obtained by Jansson & Smith (1989, 1991). These authors analysed the effect of intra-domain sources presented as examples to professionals in order to design a bicycle-rack. However, our study showed that an opposite effect is obtained when professionals (but not lay designers) are provided with interdomain sources. In this case, these sources highly facilitated the evocation of new sources.

Thus, with regard to the number of evoked sources, the evocation processes of professionals can be more easily facilitated than the ones of lay designers. In addition, professionals appear to be very sensitive to the type of sources they are provided with.

Concerning the nature of evoked sources, we found that, in the free condition, both professionals and lay designers spontaneously evoked mainly intra-domain sources. However, we observed that, in contrast to lay designers, professionals can avoid such spontaneous behaviour, when they are provided with external sources, whatever the nature of these sources. Indeed, professionals who were provided with sources mainly evoked interdomain sources, whatever the nature (intra- or interdomain) of the suggested sources.

The cognitive treatment of the suggested sources seems to be performed differently according to the designers' level of expertise. Some research showed that experienced designers are able to take into account a multiplicity of aspects of suggested sources (functional, structural, aesthetic and so on), which could allow them to activate in long-term memory very heterogeneous new sources, or conflicting aspects from different domains (see Bonnardel & Marmèche, 2003; Dorst, 1997).

## Towards enhancing creative ideas in design

Various techniques and divergent thinking guidelines – such as the classical brainstorming technique (Osborn, 1963) – have been proposed in order to foster creativity (see Dewulf & Baillie, 1999; Nickerson, 1999). In the case of professional situations, such as design, the challenge is to provide designers with a specific support in accordance with their level of expertise. Moreover, it is also necessary to provide designers with a 'contextualized' support and to present it 'at the right moment', i.e. when designers look for new ideas and progressively define their space of research. Though there is a co-evolution of problem and solution (Cross & Dorst, 1999; Dorst & Cross, 2001) as well as an iterative dialectic between problem framing and problem solving (Rittel & Webber, 1984; Simon, 1995), if suggestions occur too late in the design process, designers may not consider these suggestions, since they will be more focused on graphically representing their own design ideas.

Towards the end of adapting support to the designers' level of expertise, our findings show that only experts benefit from the presentation of external sources of inspiration, and especially of interdomain sources. Such sources allow experts to explore new conceptual domains. In contrast, for novices, the fact of being provided with sources, either intra- or interdomain, does not significantly modify the evocation of new sources. Our interpretation is that the suggested intra-domain sources are in fact very similar to the sources they would spontaneously evoke. Concerning interdomain sources, the main problem for novices would be that they cannot envision the potential utility of such sources, these sources looking for us too far from the object to design.

Such results can lead to useful benefits in two areas: enhancing novices' analogical thinking and supporting expert designers in producing creative ideas.

- For *novices*, in order to enhance analogical thinking, it appears necessary to go further than simply suggesting intra- or interdomain sources. Pedagogical actions during design education could be particularly useful for novices in order to show them how and why to use analogies for successful design problem solving (see Casakin & Goldschmidt, 1999). In particular, a specific guidance should lead them to adopt various points of view on the suggested sources, as well as to connect these sources with the object to design. For instance, novices could get specific questions related to aspects that they do not spontaneously consider (see Bonnardel & Marmèche, 2003), such as 'affective', or 'aesthetic' ones in order to benefit more from the presentation of interdomain sources.
- For *experts*, in order to enhance the production of new creative ideas, our results allow us to point out the interest of the use of computational systems for providing designers with large databases consisting of a lot of pictures or words potentially useful for creative design tasks (see Nakakoji, Yamamoto & Ohira, 2000). In particular, based on our findings, it seems interesting to provide designers with sources of inspiration *a priori* very far conceptually from the object to design. Thus, it would lead experts to extend the boundaries of the conceptual domain they spontaneously consider.

Lastly, at a more general level, it could be interesting to lead both novices and experts to become aware of the usefulness of reasoning by analogy from diverse sources, in order to become more and more creative and original.

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Nathalie Bonnardel is an Assistant Professor in the department of Cognitive and Experimental Psychology of the University of Provence. She has studied for years designers' cognitive processes, such as evaluation processes and analogy-making, in order to develop knowledge-based design systems adapted to the designers' level of expertise. She conducts her studies in the research centre in Psychology of Cognition, Language and Emotion (E.A. 3273), where she is the head of the team 'Design and use of multimedia and symbolic systems'. She is also in charge of a Master degree in 'Cognitive Ergonomics' proposed at the University of Provence. She previously conducted her research at INRIA (National Institute of Research in Computer Science and Automatique, Rocquencourt, France) as well as post-doctoral research at the University of Colorado and the Institute of Cognitive Science (Boulder, Colorado).

Evelyne Marmèche is a Research Scientist at the CNRS (National Center for Scientific Research). She has studied analogical reasoning in various areas (e.g. mathematics problems, chess games, basket games and so on). She is also interested in studying expertise in professional activities. She conducts her research at the Laboratory of Cognitive Psychology (LPC) – UMR 6146: CNRS and at the University of Provence, where she is the head of the team working on expert memory. She previously conducted her studies at the LAPSYDEE (Laboratory of Psychology, Development and Education of Children) at the University of Paris V.

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